Mathematics Education in and for Work

Geoff Wake and Keiko Yasukawa

TSG Report

In considering the meaning of 'mathematics education in and for work', we viewed 'mathematics' as being inclusive of the formal academic discipline of mathematics as well as the range of practices in which mathematics is embedded. Thus we saw 'education' to be inclusive of formal, informal and non-formal learning, that is, in educational settings (e.g. adult community education, vocational and further education) as well as in the community and workplaces. Important to the work of our group is the consideration of learning as both an individual and collective endeavour. In addition we viewed 'work' to be inclusive of paid work and unpaid work such as work in the home, and activist work in community and social settings.
In the design of this Topic Study Group (TSG), focal topics chosen included empirical, theoretical and methodological issues related to questions such as:

- How is mathematics embedded in work practices; what is this mathematics like and how is it learned?
- What mathematics do people learn in preparation for work?
- How is mathematics/numeracy valued for and in employment in different societies?

Organizers Co-chairs: Geoff Wake (UK), Keiko Yasukawa (Australia); Team Members: Corinnes Hahn (France), Ok-Kyeoung Kim (Korea), Tine Wedege (Sweden), Rudolf Straesser (Germany); Liaison IPC Member: Morten Blomhøj (Denmark).

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- How does the mathematics taught and learned for work differ/match the mathematics used in work?
- How does the mathematics learning in and for work meet people's mathematical needs in other domains of their lives?

The presentations and discussions at the meetings of the TSG touched on these questions in intersecting ways. The number of papers formally submitted to the group was relatively low and raised concerns during our meetings about the evident lack of research and other activity associated with a fundamentally important aspect of mathematics education. We expand on the views of the group in relation to this at the end of this report.

Our common pattern of working in our meetings was to have a formal presentation of papers that had been submitted to stimulate discussion which after pursuing issues raised directly by the paper explored the themes and questions identified above.

The first paper presented was Ok-Kyeong Kim's 'Pharmacists and Mathematics'. Ok-Kyeong's study examined how two pharmacists recorded the mathematics that was embedded in their everyday practices as pharmacists. Although the pharmacists did not identify much mathematics in their work, when asked to keep a journal to record the use of mathematical thinking or skills, they began to notice their use of different mathematical concepts such as ratios, proportions, measurement and percentages. What was invisible to the pharmacists themselves at the commencement of the research project slowly emerged and gained visibility, stimulated by their recording of their everyday work practices. The paper raised important questions about the difference between invisibility and absence of mathematics in work, as well as the tensions in researching 'mathematics' in workplaces: is it mathematical practice, or is it pharmaceutical practice, and who has power in the naming of this practice?

Following Ok-Kyeong's presentation, TSG participants engaged in discussions about Jaime Carvalho e Silva's paper 'The Mathematics Teaching in Vocational Schools in Portugal'. Jaime reported on an initiative taken in Portugal of potential envy by mathematics educators in many other countries. The initiative has led to a nationally agreed set of mathematics modules for a wide range of vocational courses studied in the final three years of schooling. The modules cover a wide range of topic areas ensuring that there are suitable mathematical modules for each vocational course. Modelling and statistics feature strongly, and efforts are being made to incorporate 'realistic' examples and activities. Jaime reported that the focus now is on evaluating the efficacy of these modules from a range of perspectives including those of teachers, students and workers who have studied these them. The paper and ensuing discussions highlighted the ongoing question about how should we teach mathematics in vocational courses—as separate subjects or 'invisibly' as embedded content within the specialist vocational subjects.

Invisibility of mathematics in workplace practices featured again in the presentation of Keiko Yasukawa, Stephen Black and Tony Brown's paper, 'Mathematics Education for the Worker, for the Employer, and/or for the Global

Marketplace?—An Exploratory Study of a Complex Question'. The paper was based on a work in progress on the authors' investigation of what has been described as a 'crisis' of low levels of workers' literacy and numeracy levels in Australia that, according to policy makers and industry groups, are the cause of less than desirable productivity, especially in manufacturing. Keiko presented the researchers' preliminary findings from one factory where despite everyone (production workers and their managers) acknowledging that the workers' literacy and numeracy skills are very poor in relation to any normative measures, there is no impact on productivity or quality. As in Ok-Kyeung's study, the workers generally undervalued the mathematics involved in their work, arguably because so much of the mathematics was deeply embedded in the software systems they were using (for example, the computer aided design package used for modeling 3-dimensional objects). Their study did however point to an area of numeracy and literacy need that was (unsurprisingly) not identified by industry and employer groups: the literacy and numeracy practices required by workers, such as low-paid production workers, to critically interpret and negotiate to improve their working conditions.

The final paper presentation was Geoff Wake's paper, 'Seeking principles of design of general mathematics curricula informed by research of use of mathematics in workplace contexts'. Geoff's paper addresses the important question of how the mathematics curriculum can support students' transition from one mathematical (eg formal learning in school) context to another (eg informal learning in the workplace). Drawing on his previous studies of ways in which mathematics is often 'black-boxed', that is deeply embedded and invisible within workplace artifacts or procedures, and on learning as identity work among students in transition from school to work, Geoff articulated design principles for a general mathematics curriculum. These principles include viewing mathematics as not just an object of study, but as a practice that facilitates communication within, membership of, and transformation of a community of practice. Geoff's paper emphasized the value of using research on workplace practices to inform and transform general mathematics curriculum into one that affords students with authentic experiences of learning and becoming users and producers of mathematics.

A presentation of a poster by Minoru Ito based on his and his colleagues Tadashi Aoki and Akihiko Shimano on 'Partnership Program of Mathematics and Science Education in Japan' shifted the focus of the TSG members to a different kind of study. Minoru and his colleagues were involved in a partnership program between his university and a city in Japan to engage university academics and students to design and facilitate engaging mathematical experiences for students in the city's schools. This was an innovative and visionary project to address concerns both about growing disengagement of school students in mathematics and the expected demand of increased mathematical and technological knowledge that these same students are likely to face in their future to address the complex economic and environmental challenges in their society.

Lisa Bjorklund Boistrup and Marie Jacobson's poster presentation took a different but equally big picture view of mathematics education in and for work, in their discussion of the project led by Tine Wedege, 'Adults' mathematics: In work

and for school'. Their project was still in its early stages, but aims to uncover the relationship between the mathematics containing competencies that adults encounter in their workplaces with the mathematics learning demands that students face in their vocational studies.

The presentations in this TSG represented studies being conducted in several European countries—the UK, Portugal and Sweden, the USA, Japan and Australia, about a range of workplace and educational contexts—pharmacies, factories, high schools, vocational schools, nursing and caring work, and transport and garages, with each raising salient issues. The value of understanding mathematics as a social practice was shared by many of the presenters and discussion participants. That there was a tension between learning mathematics as part of a workplace practice and learning mathematics more explicitly in order to be able to critique and perhaps transform existing practices was acknowledged, as well as its corollary, which is the question of who should teach mathematics in vocational preparation courses—the vocational specialist or a mathematics specialist?

The TSG presentations and discussions also highlighted the many theoretical resources that are informing research being undertaken to understand mathematics education in and for work. Along with the presenters' own prior research, the work of other colleagues in workplace mathematics research including Hoyles and Noss, Wedege and Zevenbergen were drawn upon by several presenters. Socio-cultural theories of learning including Vygotsky's/L'eontev's/Engestrom's activity theory, Lave's situated cognition theory and Wenger's ideas of community of practice featured in several of the papers, reflecting the need to account for the collective nature of mathematical practices in workplaces.

In the same way that Geoff Wake's paper highlighted the importance of workplace research informing general mathematics curriculum design, research in vocational and workplace mathematics education should perhaps be more strongly informing what happens in mathematics learning at earlier stages of schooling. A final discussion of the group focused on these and related issues. Members of the group expressed their concerns at the relative lack of interest of the ICME community in this area of research given the important role that mathematics education plays in preparing young people for future work and critical citizenship. It was resolved that the co-chairs would be pro-active in raising the profile of the issues that emerged during discussions of the group and would seek to explore the possibility of a future ICME survey group providing an overview of the state of play of mathematics education in and for work across a range of cultural settings around the world.

Final Timetable

Tuesday, July 10 Session 1—10.30–12.00
10.30–10.45 Introductions and opening remarks: Geoff Wake and Keiko Yasukawa
10.45–11.20 Presenter: Ok-Kyeong Kim—Pharmacists and Mathematics, Discussant: Jaime Silva

11.20–11.55 Presenter: Olda Covian-Chavez—Mathematics applications in Topography: What elements for the training? (*not presented*), Discussant: Geoff Wake
11.55–12.00 Closing remarks
Wednesday, July 11 Session 2—10.30–12.00
10.30–10.45 Introductions and recap of previous day: Geoff Wake and Keiko Yasukawa
10.45–11.20 Presenter: Jaime Silva—The mathematics teaching in Vocational Schools in Portugal, Discussant: Geoff Wake
11.20–11.55 Presenter: Keiko Yasukawa—Mathematics Education for the Worker, for the Employer, and/or for the Global Marketplace?—An Exploratory Study of a Complex Question, Discussant: Ok-Kyeong Kim
11:55–12:00 Closing Remarks
Friday, July 13 Session 3—11.00–12.30
10.30–10.45 Introductions and recap of previous day: Geoff Wake and Keiko Yasukawa
10.45–11.20 Presenter: Geoff Wake- Seeking principles of design of general mathematics curricula informed by research of use of mathematics in workplace contexts, Discussant: Keiko Yasukawa
11.20–11.55 Overall threads and observations: Rudolf Strasser
11.55–12.00 Closing remarks
Saturday, July 14 Session 4—10.30–12.00
Poster presentations
Presenter: Minoru Ito—Partnership Program of Mathematics and Science Education in Japan
Presenter: Lisa Bjorklund Boistrup—Adults' mathematics: In work and for school
General discussions and future.